

REAL TIME ANIMATION OF SPACE PLASMA PHENOMENA

by

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ABSTRACT

In pursuit of real-time animation of computer simulated space plasma phenomena, we have rewritten code for the MPP. The program creates a dynamic representation of the global bowshock which is based on actual spacecraft data and designed for three-dimensional graphic output. This output consists of time slice sequences which make up the frames of the animation. With the MPP, 16384, 512 or 4 frames can be calculated simultaneously depending upon which characteristic is being computed. The run time has been greatly reduced which promotes the rapid sequence of images and makes real-time animation a foreseeable goal. The addition of more complex phenomenology in the constructed computer images is now possible and work proceeds to generate these images.

INTRODUCTION

With several spacecraft making measurements in space, the ability to explore global phenomena is greatly increased. However, analysis and integration of the massive amounts of data require new techniques for gaining insight into the optically invisible, space plasma phenomena. Three dimensional real time animation will be very powerful tool and will allow scientists to correlate data beyond merely comparing static plots of multiple variables looking for similarities or dissimilarities. Traditional computing capability cannot deliver the rapid display of sequential which

simulate "views" of the earth's plasma layers as they change with solar wind conditions. In our initial effort, data from the ISEE-1 and ISEE-3 spacecraft are used to create a dynamic three-dimensional model of the earth's bowshock. Real time animation (which we define as a frame every images second or less) will allow the scientist to interactively manipulate and verify his model. This interaction will consist of accessing any desired data set, changing model equations and constants, and inspecting selected features. At present, we think the MPP very promising for achieving our objectives and beyond.

PROBLEM

Animation is notoriously demanding on memory and machine speed to achieve realistic motion directly from the computer itself. For our previous production, we used a VAX 750 and Evans and Sutherland Multi Picture System. Typically, a 350 frame film took 3 1/2 hours to run. The time factor forced us to compute the entire sequence of data and store the bowshock variables onto magnetic tape. Then, the images were rendered based on the data on tape and filmed frame by frame. The chemical film processing took at least a week and the film to-video conversion took at least two weeks. Turn-around time was further increased due to the raw data being on magnetic tapes that were specially made and shipped to us.

The problem is to eliminate the multistage process, the unacceptable executions times, and the uncontrollable multimedia interfaces between the data input and the animated output scene. We would like to eliminate chemical stages altogether.

APPROACH AND RESULTS

Communications. Since our offices are on the west coast, our interactions with the MPP system must take place through one or more communication paths. We have relied heavily on the Space Physics Analysis Network (SPAN) for transferring code and testing results. Telephone conversations with our assigned MPP advisors and a 7 day trip to the MPP facility also allowed work to progress. We favor SPAN because, aside from being charter organizers and supporters of the system, we routinely employ the network to obtain the satellite data used as input to the graphic models we want to animate.

Image Computation. Our initial effort with MPP has been to reproduce the animation sequence already completed with the former system. A frame of the animation represents the Earth's bowshock which is depicted as discrete rings. The number of rings are determined by the data sampling rate and the hyperbolic model. The rings are divided into quasi-perpendicular (green) and quasi-parallel (blue) sections based on local magnetic field and the normal to the shock in the B-X-plane. The "predicted" bowshock structure is based on and verified by spacecraft data from ISEE-3 (density, solar wind parameters, magnetic field vectors) and ISEE-1 (shock structural observations). Each frame of the animation is independent and requires reading and solving its own set of data values. There are 32 to 4096 values to be calculated for each variable per frame. Due to computational time restrictions, the model is very

simplified. Many assumptions are made about solar wind delivery angle and delay times. We were confined by low data sampling rates and low resolution inputs. Both the model and its assumptions could be tested by recycling our animation sequence through changes in parameters and algorithms.

In the MPP system, we still separate the image computation from the display process, but whole frames of 4096 points can now be calculated together instead of only one point at a time. Figure 1 shows how the variables can be mapped to the MPP parallel arrays. The variables that are related to the 32 rings per frame are calculated 512 frames at a time, others that are related to the points can be calculated 4 frames at a time. The MPP only takes 10 minutes to compute 350 frames (A vast improvement from the VAX). The majority of the time is spent storing data to and from disk.

Image Production. With the number crunching aspect solved, the remaining problem is the graphics. There are no facilities on the MPP to create the picture. Through the SPAN network, the data files from the MPP are transferred to other computers (such as NSSDC) to be rendered on local terminal. The data files require 512 blocks plus 384 blocks for each group of four images. Since the graphics through the network consumes much storage space and takes too much time for real time animation, it is currently part of the test process only.

CONCLUSIONS

The capabilities of the MPP are bringing us closer to the goal of interactive animation. The MPP and its access through SPAN allow increases in both available data sets and model complexity. Any data set can be requested from UCLA, JPL, or other data nodes through the network rather than by magnetic tape. With minutes rather than

hours of computation time, the model equations can be adjusted (and will be in the future). With the dramatic increase in speed realized by the MPP, the scientist's interaction with the data through real-time animation becomes more than just a pipe-dream.

FUTURE

Graphic Improvements. We plan to include raster representations. The graphics will continue to be done by passing the data files through the network but we will use a local computer to allow real time performance. An affordable means of recording from graphic monitor to video tape is desirable to easily preserve the results for presentation to the scientific community.

Model Improvements. As soon as regular display of MPP-produced scenes is implemented at TRW with acceptable turnaround times, we shall begin

altering the parameters, assumptions, and algorithms of our existing model to find better conformity between predicted and measured phenomena.

Model Enhancements and Enlargements. We will be adding complexity to our models to allow more than two shock structural types, several foreshock surfaces, magnetopause depiction, and magnetosheath dynamics.

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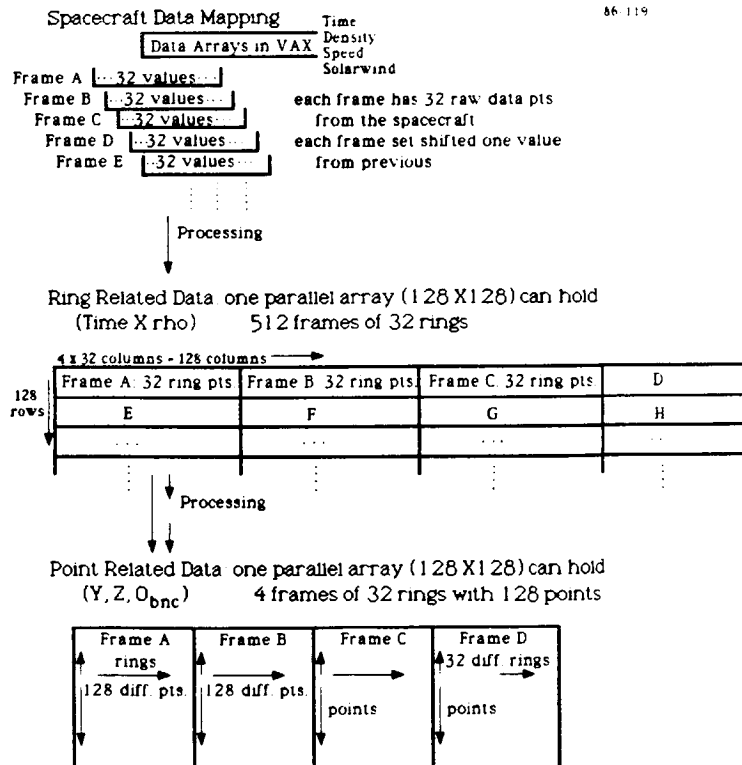


Figure 1 Mapping of Parallel Arrays